Modeling the X-ray emission from Tycho SNR

Important physical processes in young SNRs

Daria Kosenko

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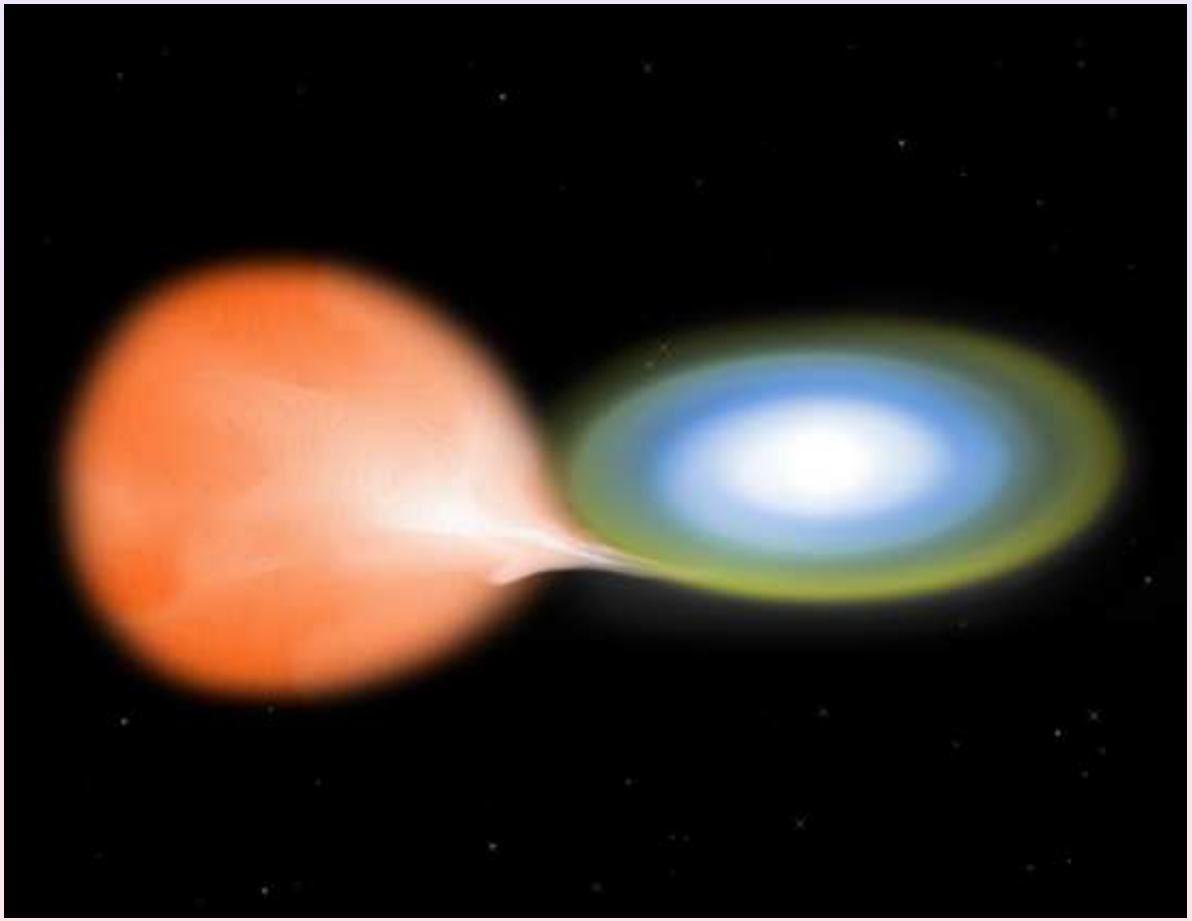
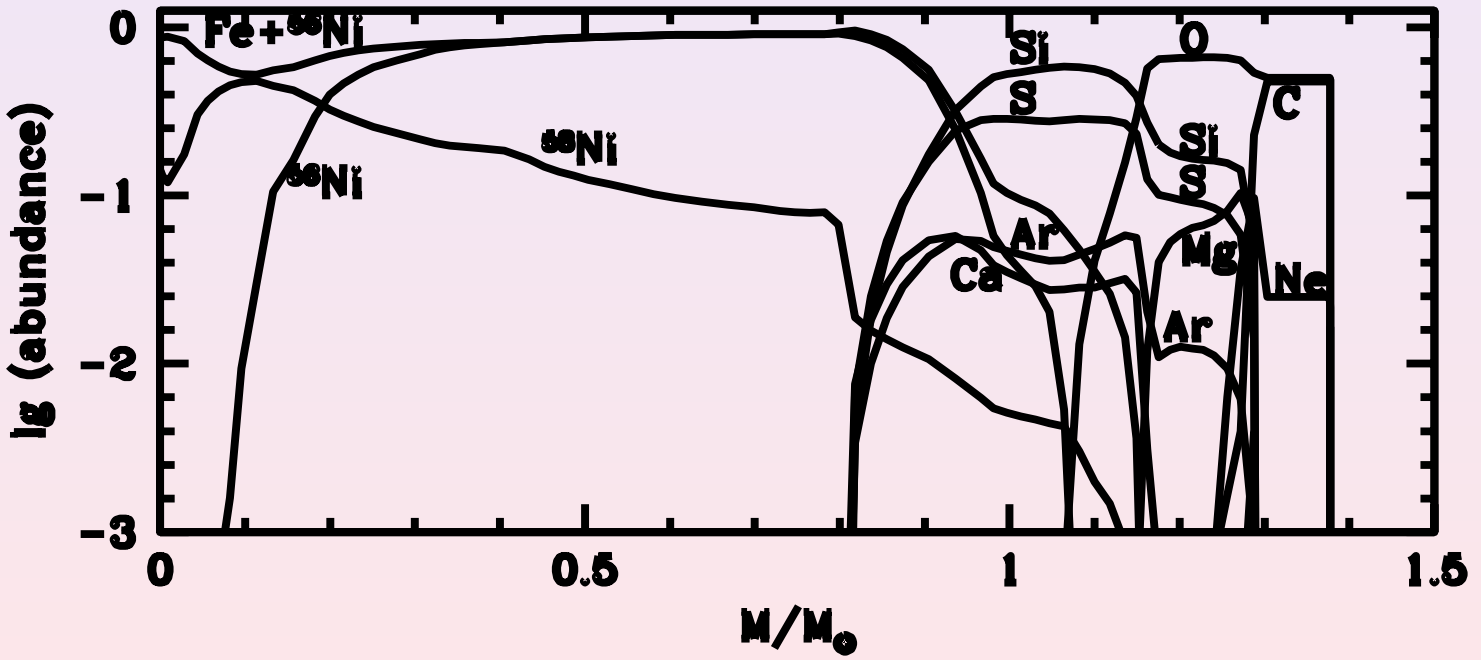
SN Ia — thermonuclear explosion of WD



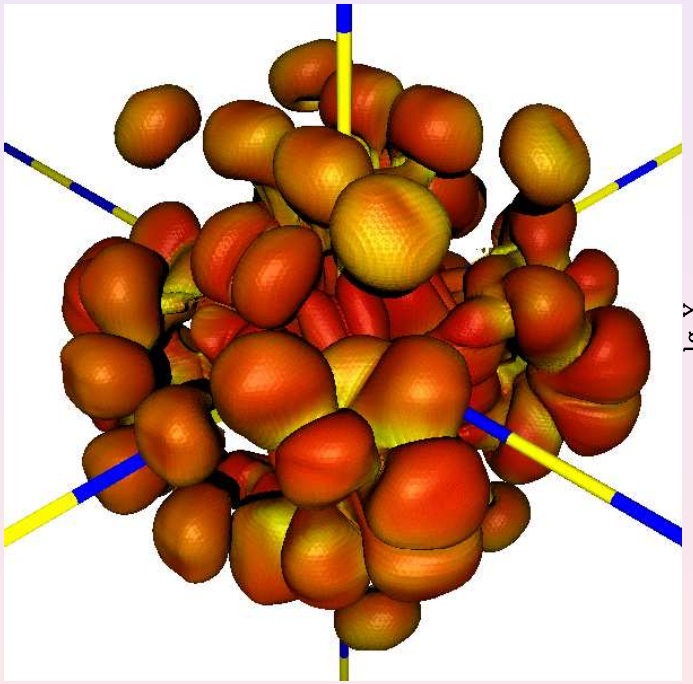
Elements distribution in SN ejecta

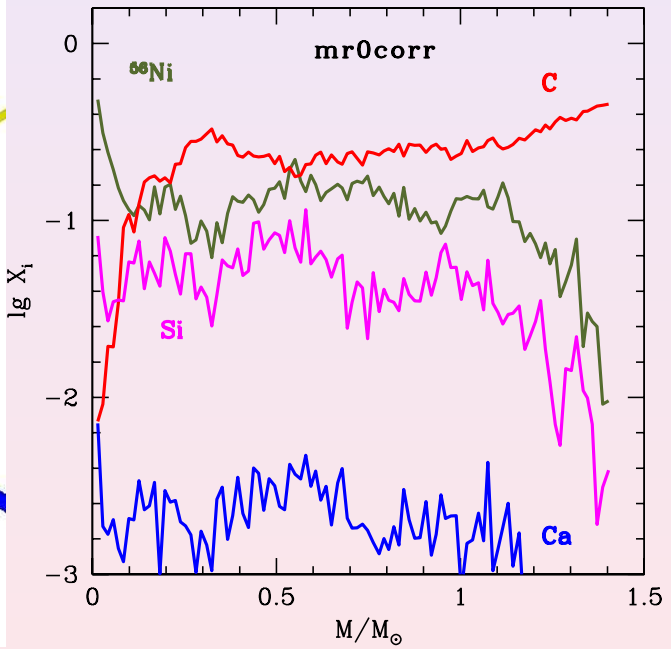
W7 (Nomoto, 1984) — parametric model



Elements distribution in SN ejecta

MR0 (Reinecke, 2002) — "first principle" model

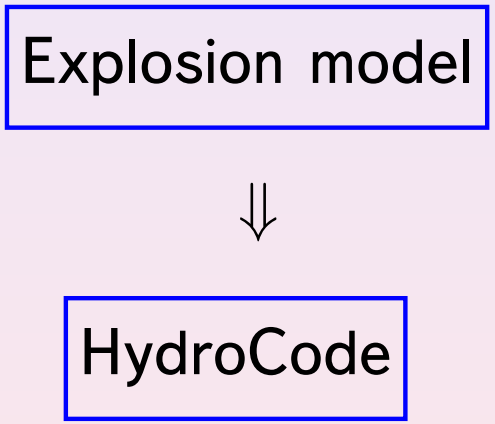




Testing SN Ia models

Explosion model

Testing SN Ia models



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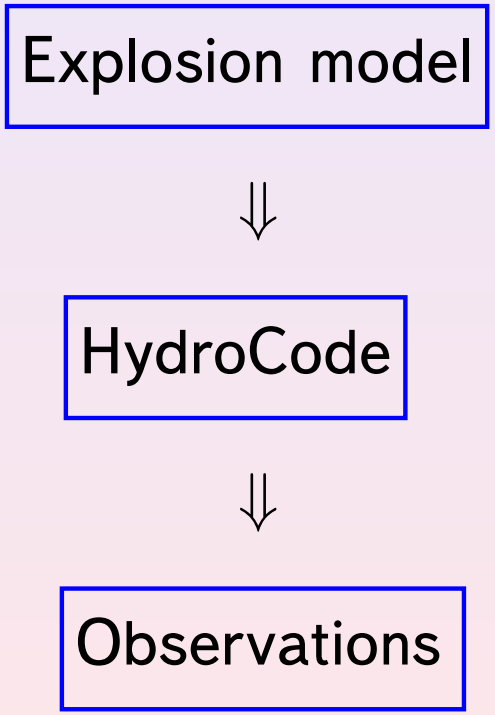
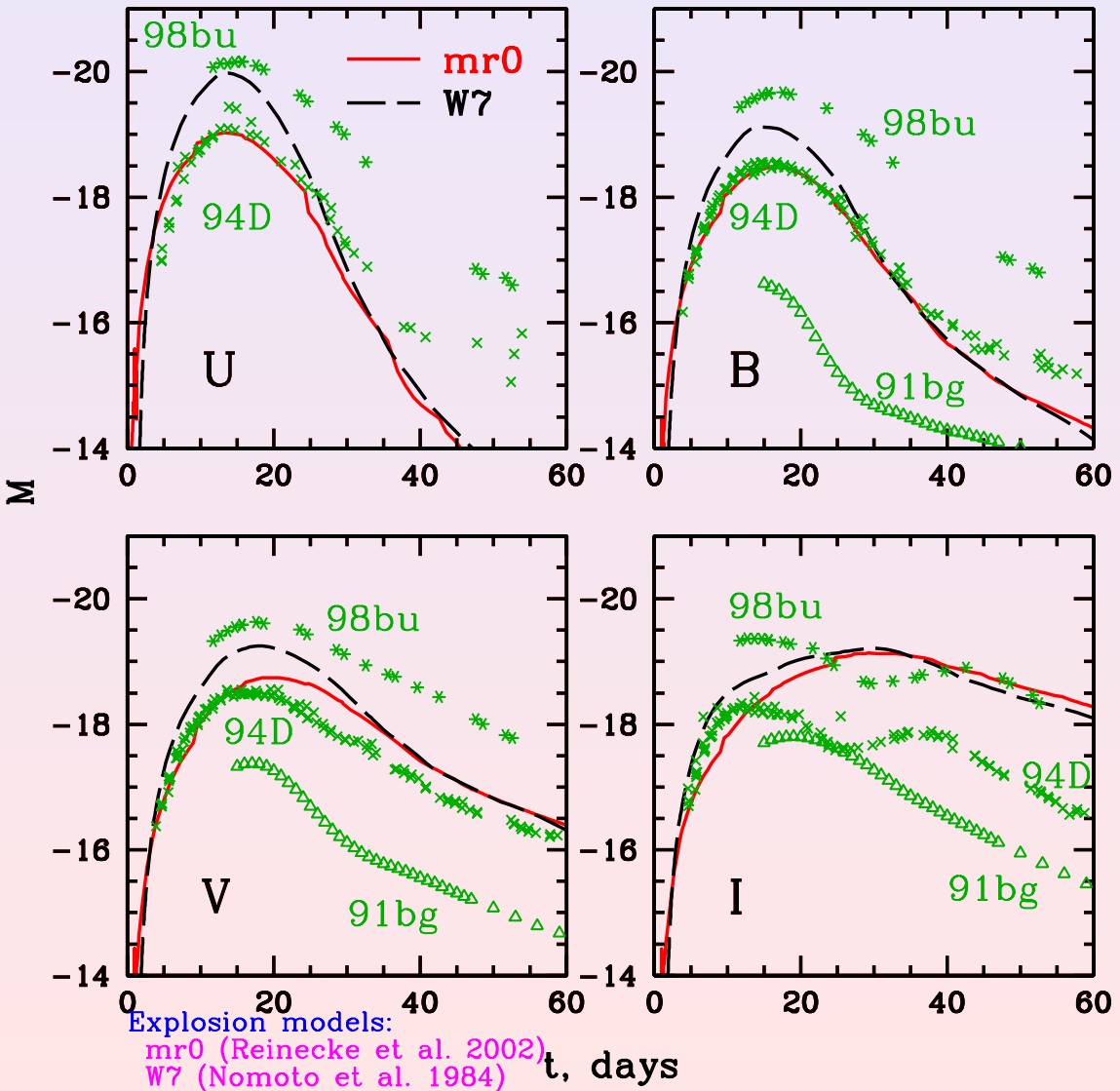


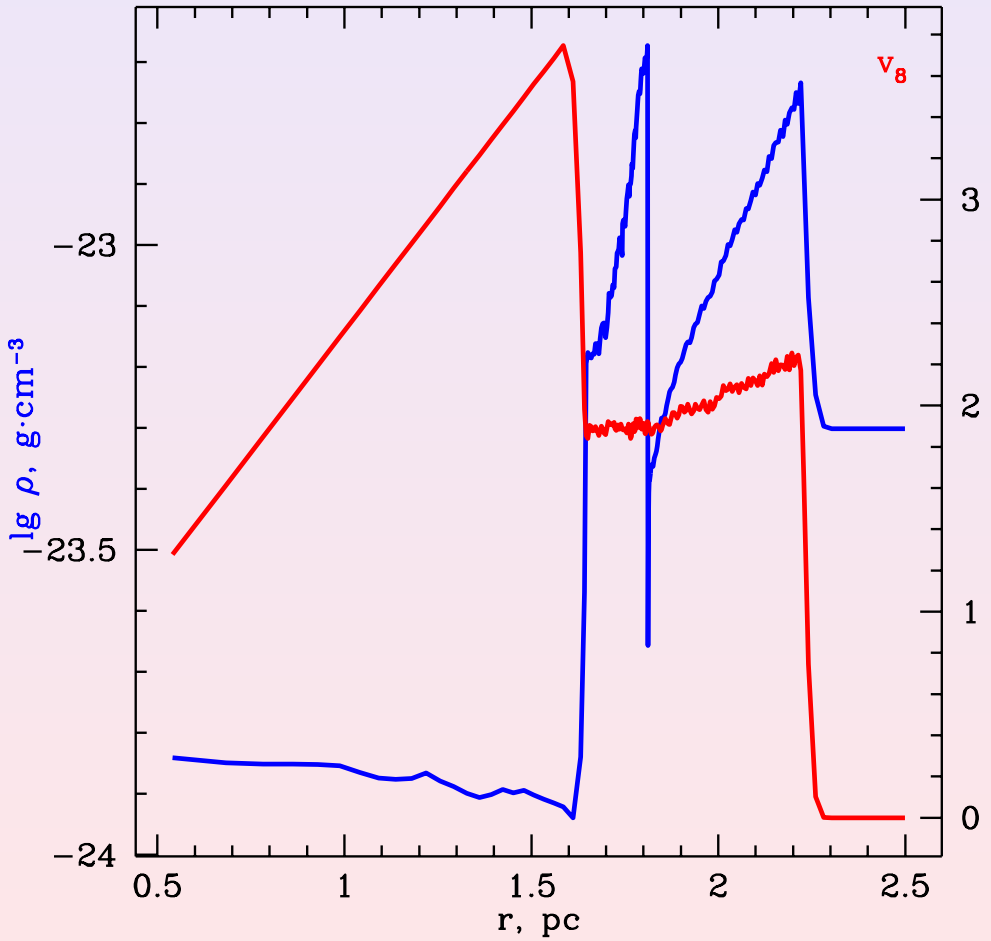
Testing on lightcurves

Sorokina, Blinnikov, 2002



Explosion models:
mr0 (Reinecke et al. 2002)
W7 (Nomoto et al. 1984)

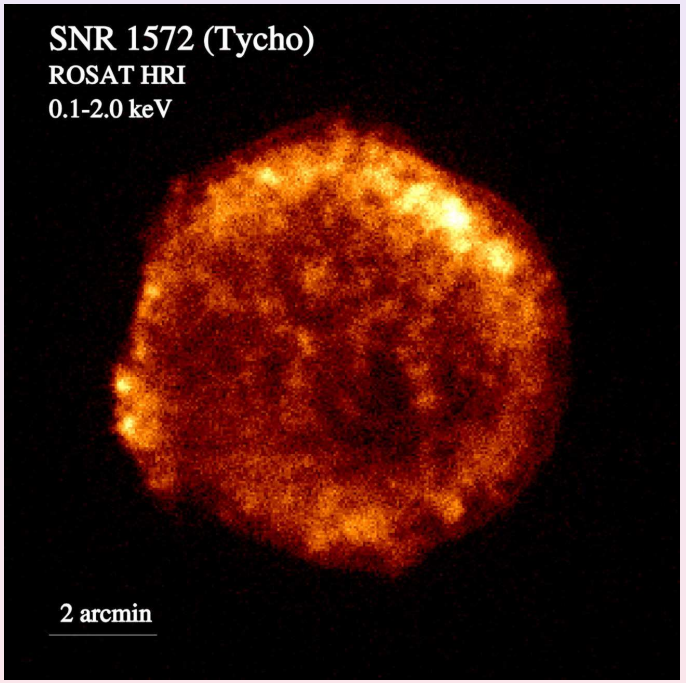
Sedov stage — young SNR



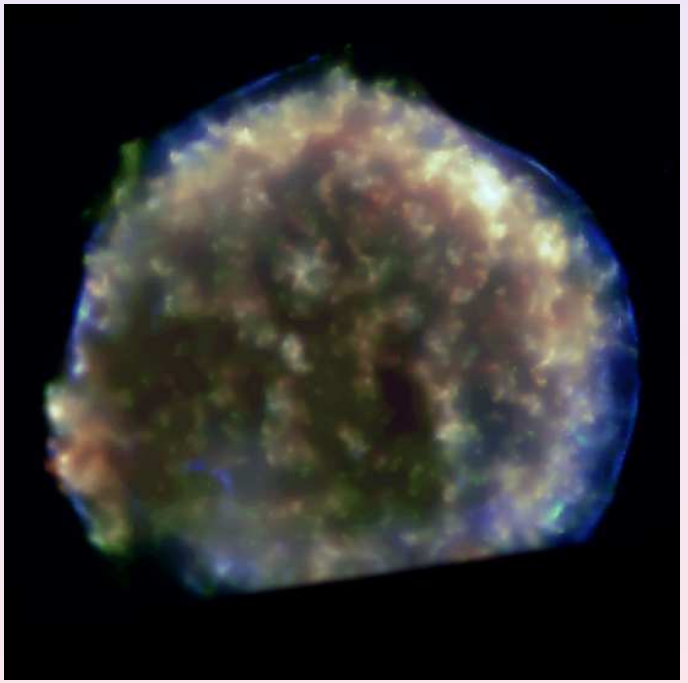
200 years

Testing on X-ray from young SNRs

ROSAT



Chandra



430 years, 8', 1.5-3 kpc

Testing on X-ray from young SNRs

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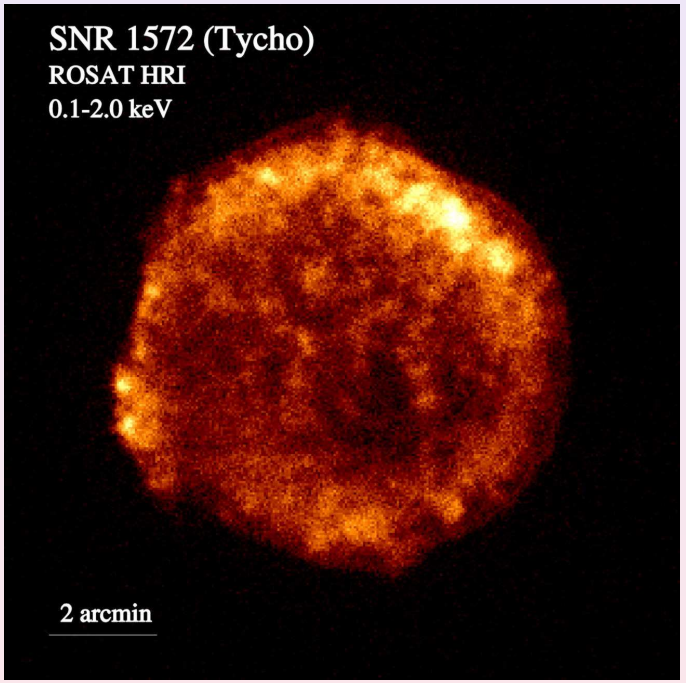

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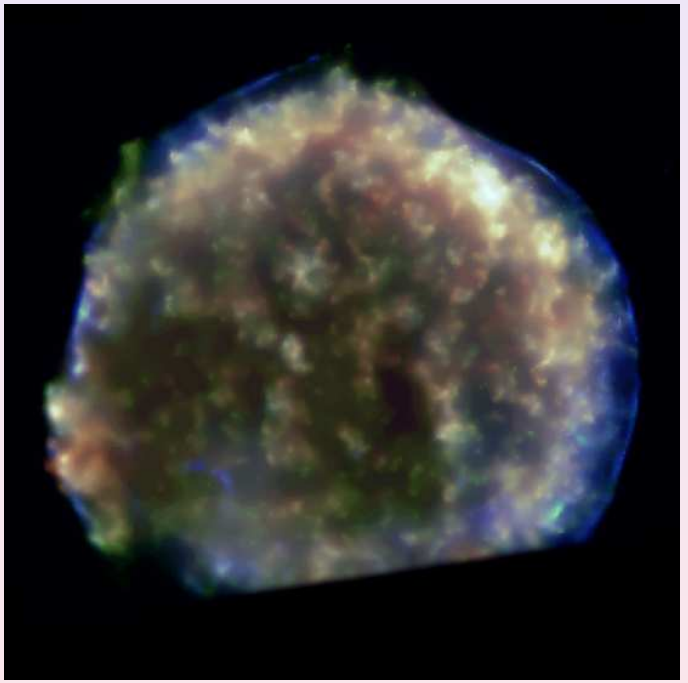

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Numerical simulations

SUPREMNA: 1D radiative hydrocode

- energy losses
- NEI — hydrodynamic evolution: self-consistent calculation
- thermal conduction
- non-Coulomb energy exchange between electrons and ions

parameterized

Numerical simulations

SUPREMNA: 1D radiative hydrocode

- energy losses
- NEI — hydrodynamic evolution: self-consistent calculation
  - in each mesh, at every time step for all ions of 15 elements
  - processes: collisional ionization, autoionization, photoionization, dielectric ionization, charge transfer
- thermal conduction
- non-Coulomb energy exchange between electrons and ions

parameterized

Numerical simulations

SUPREMNA: 1D radiative hydrocode

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Numerical simulations

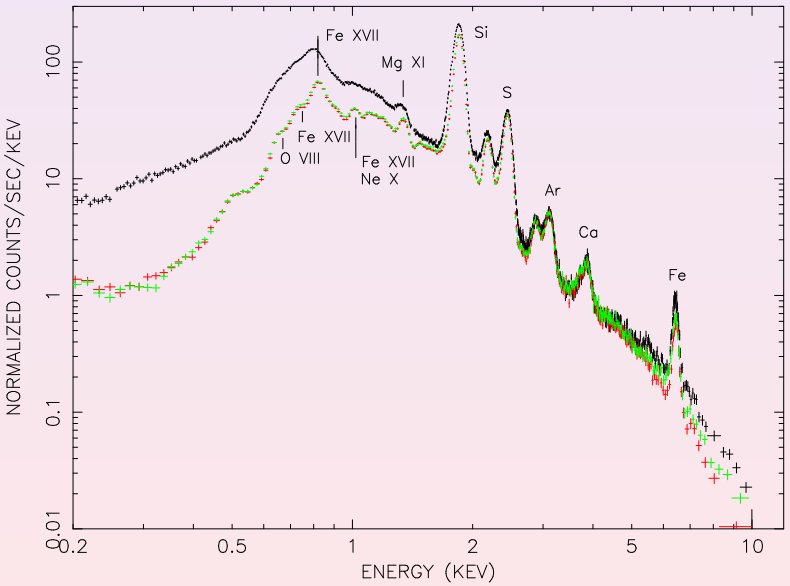
SUPREMNA: 1D radiative hydrocode

- energy losses
- NEI — hydrodynamic evolution: self-consistent calculation
- thermal conduction $[C_{kl}]$
- non-Coulomb energy exchange between electrons and ions [q]

parameterized

Tycho SNR (XMM-Newton) — spectrum

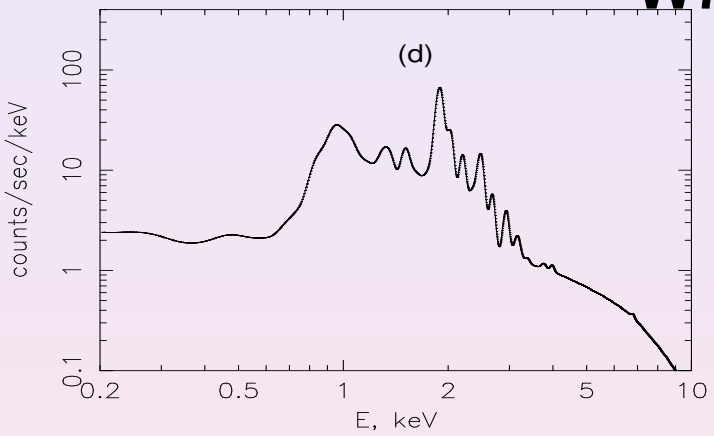
Decourchelle et al. (2001)



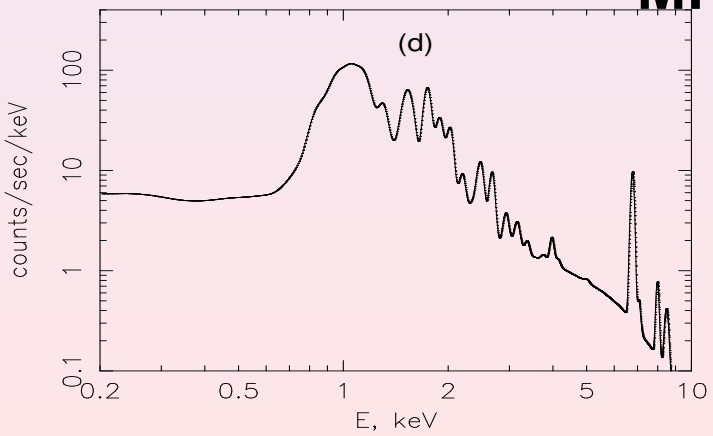
XMM-Newton: EPIC MOS/PN

Sorokina et al (2004)

W7

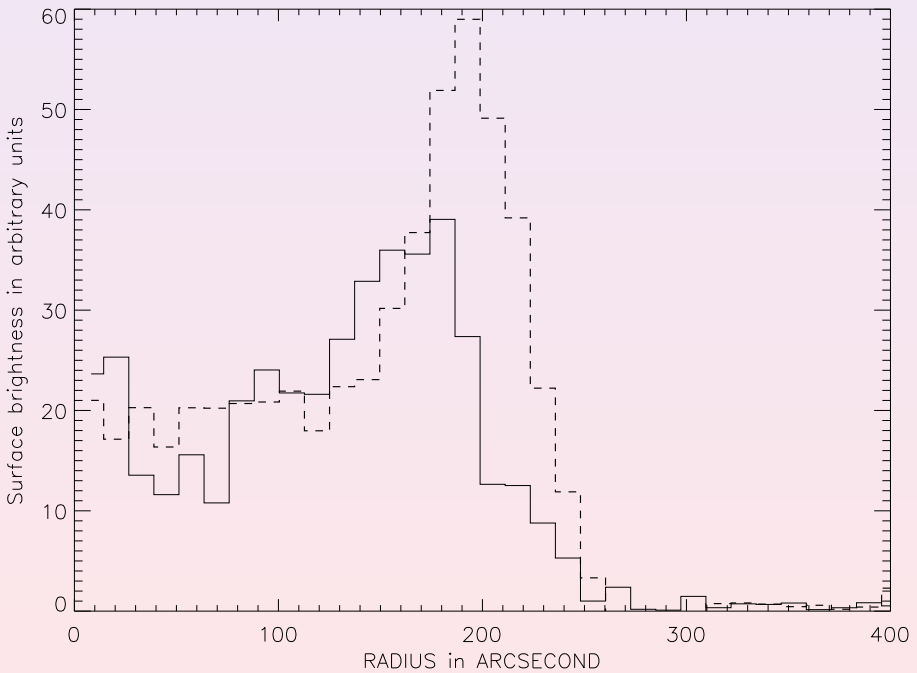


MR0



Tycho SNR (XMM-Newton) — brightness profiles

Decourchelle et al (2001)



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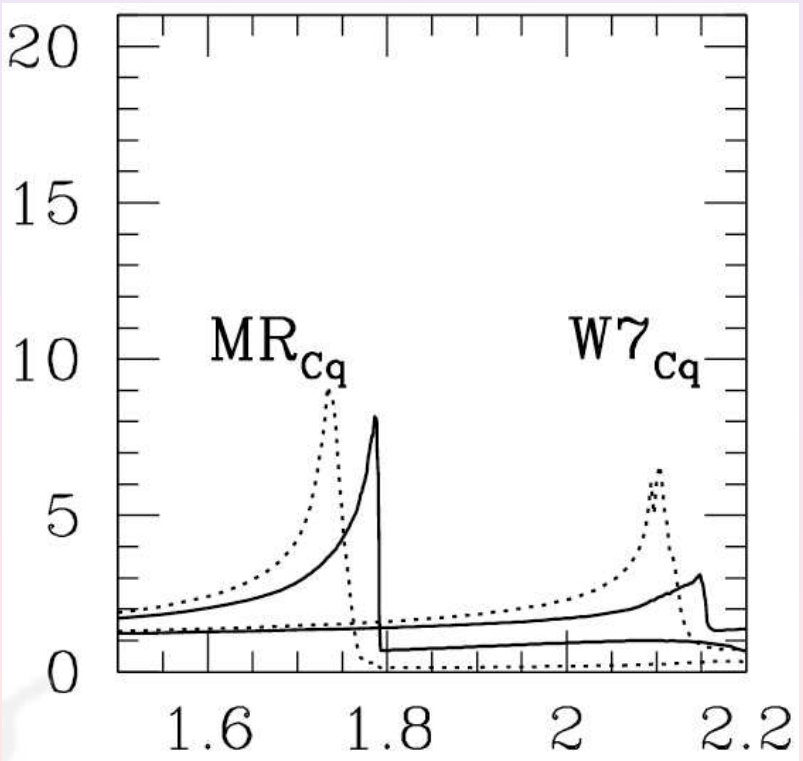


Fe XVII — dashed; Fe K —solid

Collisional inner-shell ionization

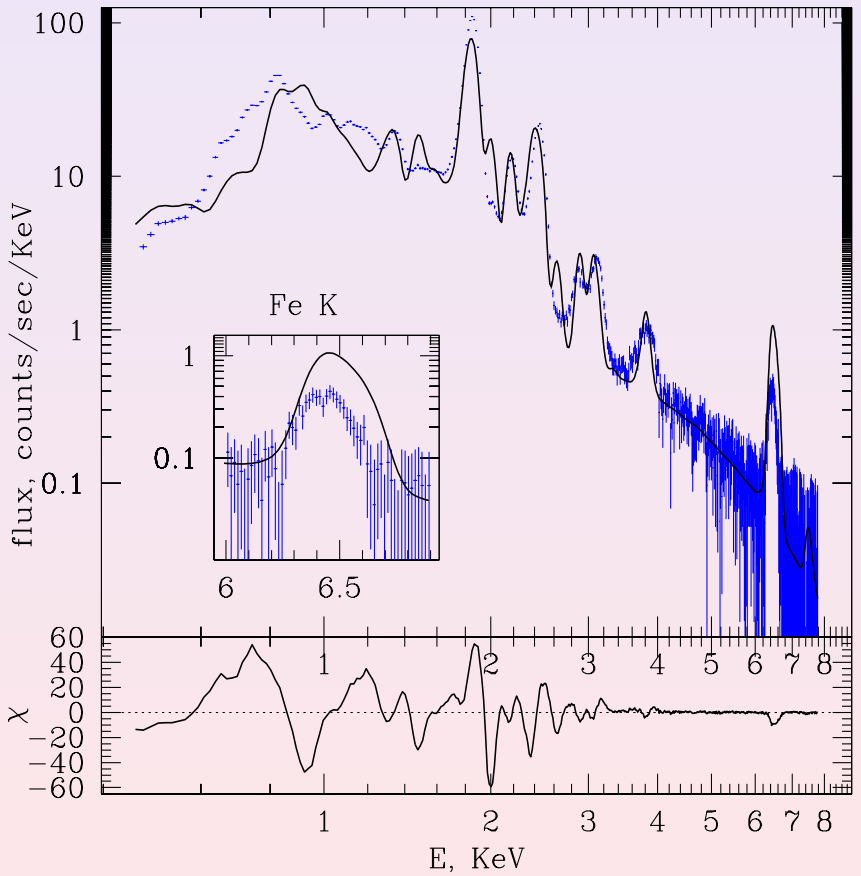
underionized plasma

Collisional inner-shell ionization

$\Uparrow$

underionized plasma

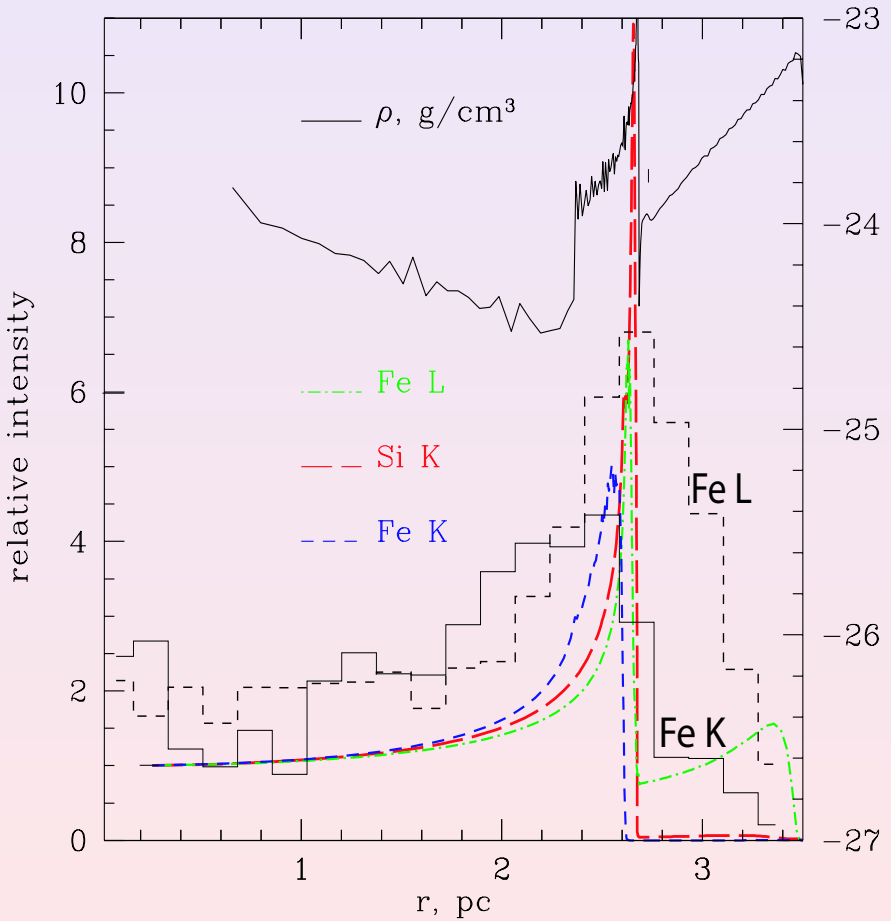
Spectrum fitting (W7)



ρ_{CSM}, g/cm^{-3}	1.8×10^{-24}
q	0.93
C_{kl}	0.0085
N_H, cm^{-2}	3.7×10^{21}

Distance to the SNR	
spectrum	1.3 kpc
brightness profiles	3.1 kpc

Brightness profiles (W7)



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Conclusions

- Estimations of a SNR parameters, distance measurements
- W7 produces a “good” fit to the observations (was rejected)
- Fe K centroid, distance to the remnant $\Rightarrow$ explosion model for Tycho SN should be less energetic compared to W7
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more models to go...
more SNRs to go...

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